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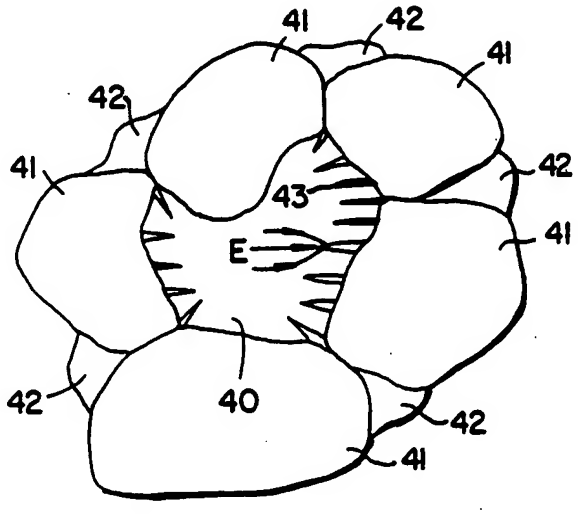

(57) Abstract

A multitude of microplasma fusion chambers provides a synergism between the plasma discharges and the deuterated microprotrusions (whiskers) (43) on the surrounding solid surfaces (41). Impurity gases such as D_2O,TeD_3,UD_3,ThD_4,SbT_3,IT,AsT_3,ST_2, etc. in which there is an atom much heavier than deuterium (D) or tritium (T) serve as an adjunct acceleration mechanism for the D ions by double-backscattering, and knock-on. The main hydrogen isotope gas such as D_2 and/or T_2 is introduced at a pressure exceeding 10 atmospheres. A pulsed magnetic field in synchronism with a pulsed electric field enhances the performance of the device. Higher temperature operation is facilitated by using hydrogen absorbing metals such as Zr and V. Among other functions, whiskers (43) on the discharge surfaces (41) serve to focus and enhance the electric field. Means are provided for producing the whiskers (43).

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SOLID STATE SURFACE MICRO-PLASMA FUSION DEVICE

FIELD OF THE INVENTION

This invention relates generally to nuclear fusion in a combination solid state cell and gaseous discharge device in which a pulsed voltage is applied.

BACKGROUND OF THE INVENTION

Nuclear fusion is an ideal source of energy since one of the potential fuels, deuterium (D), occurs in vast amounts in the oceans. In addition there is relatively less radioactivity associated with it compared with nuclear fission as an energy source. Because of the conversion of mass to energy, substantially more energy can be produced than the energy input into the system. Much work has been done for over three decades on high temperature plasma controlled fusion. However, the achievement of sustained controlled fusion in high-temperature plasmas still seems remote.

Professor Yeong Ell Kim, the co-inventor of this instant invention, has published a directly related paper entitled *Nuclear Physics Interpretation of Cold Fusion and Optimal Designs for Gas/Solid-State Fusion Device* in the Special Symposium Proceedings of the WorldHydrogen Energy Conference #8, Honolulu, Hawaii, July 22-27, 1990, p. 223-232 in which he presented a theoretical analysis of micro-plasma fusion. There is also a short report by Claytor et al, LA-UR-89-39-46 entitled TRITIUM AND NEUTRON MEASUREMENTS OF A SOLID STATE CELL which describes experiments with an embrionic micro-plasma fusion device. Whereas, there are some similarities between their device and ours, we herein present novel features to be described in detail that allow for improved performance such as the incorporation of a magnetic field, the two stage application of voltage, and the utilization of whiskers. T. N. Claytor et al at the Los Alamos National Laboratory (LANL) have made measurements of tritium (T) and neutrons (n) emanating from a solid state cell. Although they do not know the mechanism, they have strong experimental evidence for nuclear fusion. We have a model that explains the data, and permits us to make improvements upon their device.

OBJECTS OF THE INVENTION

The general objective of the present invention is enhanced fusion production in solid state cells at substantially higher rates than has been previously achieved. One object of this invention is to increase the capability of the device to cope with higher temperatures. A more specific object of this invention is to increase the operating temperature of the device. Another object is to increase the fusion rate by increasing the operating pressure of the device. An object of this invention is to provide a magnetic field to increase the fusion rate. A further object of this invention is to provide heavy partner atoms to serve as an adjunct accelerating mechanism by double backscattering of fusible isotopes such as deuterium and tritium. Another object of the invention is to provide whiskers on the cathodic surfaces to focus and enhance the electric field. Yet another object of this invention is to introduce frozen fusible isotope whiskers, such as frozen D_2, in the multitude of microscopic pockets to provide a high density fusion plasma. Further objects, features, and manifestations of the invention will be more readily apparent from the detailed description and appended claims when taken in conjunction with the accompanying drawings.

SUMMARY OF THE INVENTION

We have a unique understanding of the operation of this device as a multitude of Microplasma Fusion Chambers in which there is a synergism between the plasma discharges of the D in the tiny pockets formed between the palladium deuteride (PdD) powders, and as defined by the PdD surfaces. The insulating interfaces (made of Si, SiO_2 etc.) serve to break up the macroscopic discharge into small regions, where the PdD further breaks it up into micro-regions.

Impurity gases such as D_2O, TeD_3, SbD_3, ID, AsD_3, SD_2, UD_3,ThD_4, T_2O, TeT_3, SbT_3, IT, AsT_3, ST_2, UT_3,ThT_4 etc. in which there is an atom much heavier than deuterium (D) or tritium (T) serve as an adjunct acceleration mechanism for the D ions. These mechanisms involve Rutherford double-backscattering, and knock-on followed by double backscattering (triple scattering) at the

gas-metal interface. For example in double-backscattering, a D backscattered from a Pd or Ti (titanium) surface atom and then backscattered again by an O (oxygen), will increase its energy by a factor ~ 6. Two such backscatterings will enhance its energy by a factor ~ 40. A knock-on occurs when a heavy incoming atom such as an O hits a target D imparting energy and momentum to this D. The D can then gain further energy by a double-backscattering process as described above.

Since the velocity gained from the electric field by the consituents of the ionized molecule is the same, the heavier partner atom has more energy by the ratio of its mass to that of the fusible isotope. Some of this extra energy is imparted to the fusible isotope by back-scattering, and knock-on processes.

The coverage of D on the pocket surfaces should be maximized. Thus in the preferred embodiment, the total number of D_2 gas pockets and the total surface area of deuterated metal (such as Pd and Ti) exposed to these pockets is maximized. It is preferable to have D on a target surface (surface bombarded by D ions) that is free of oxide. It is desirable to have heavy atomic projectile partners such as B, O, S, As, I, Te, Th, and U in combination with a fusible isotope such as D or T in gaseous molecular form as hydrides. The heavy atoms more efficiently sputter the oxide off the target whiskers. Moreover, when a projectile D ion strikes the surface, it may backscatter from a heavy surface target atom such as Pd, Ti, Zr, or V and collide and backscatter from a heavy incoming projectile atom. This double backscattering of a D enhances the D's energy. The ratio of its final to initial kinetic energy is:

$(KE_f/KE_i)_1 = [\{(M_t-m)/(M_t+m)\}\{(M_p-m)/(M_p+m)\} + 2\ M_p/(M_p+m)]^2$,

after one double backscattering, where M_t, m, and M_p are the masses of the target atom, the deuteron, and the heavy projectile partner atom respectively. After two double backscatterings, the ratio of the final to initial kinetic energy is: $(KE_f/KE_i)_2 = (KE_f/KE_i)^2$. Table 1 lists the increased kinetic energy from backscattering for various elements.

In practicing the preferred embodiment of the invention,

the fusion reaction takes place by impact of energetic deuterons (d's) at the surface of the PdD interface of the micro-pocket deuterium plasmas formed between the PdD powders. In our view, it is the collision of the high energy d's of the Maxwell-Boltzmann energy distribution with the high density d's at the surface of the PdD that is largely responsible for the fusion reactions.

One of the major problems in large machine Controlled Nuclear Fusion is that of containment i.e. keeping the high energy particles in the reaction region. If they diffuse out, the reaction rate drops precipitously. To provide confinement, large expensive magnets are used. In our teaching, the Solid State MicroPlasma Fusion Device circumvents the containment problem of large machines in that almost every small plasma fusion pocket (which can be thought of as a miniature fusion machine) is surrounded by a multitude of other pockets. The very smallness and independence of these regions circumvents instability problems that plague large fusion machines as each plasma region is very small and acts independently of the others. There are other advantages to the small plasma fusion pockets, related to our invention, as we will further describe.

By dividing up the large region between the cathode and anode of the external power supply into a multitude of small regions, a higher voltage and hence a higher electric field (total voltage/ total gap) can be applied. The energy gained between collisions of the d's is proportional to the electric field times the mean free path of the d's. The higher electric field imparts more energy to the d's, and the fusion rate increases rapidly with increased energy of the d's. Thus we teach something not taught by Claytor et al. Our teaching is that smaller powders, densely packed, which thus produce smaller pockets and greater surface area give better results. In more precise terms, the length of the pockets should be smaller than ~ 8mm , and larger than the mean free path, l, of the d's. Our teaching is that pressures higher than 10 atm. will allow higher voltages, since the breakdown voltage increases with pressure. The higher voltages will impart more energy to the d's. An oxide

coating around each particle of the powder helps to electrically isolate the particles and the pockets so that the applied electric field is not shorted out as next described.

The purpose of the oxide coating on the deuterated metal (perforated plates, powders, honeycomb slabs, etc.) is to electrically isolate the con- ducting regions. Thus the total electric field is divided up into very small regions each of which has much higher voltage and hence higher electric field than the electric field that would be present if either the regions were shorted out by being shunted by conductor around them, or if there were just a macroscopic electric field formed by the voltage applied between the two end plates of the device. Dividing up the total space into small regions permits application of a much higher voltage before the voltage breaks down and there is a discharge. However the oxide coating is not desired at the interface surface between the plasma and solid. It is preferable to have this surface covered completely with a fusible isotope such as deuterium. Sputtering off of the oxide layer in this region will occur during the electrical discharge, exposing a fresh surface of deuterium. It is in this process that the whiskers serve an additional important function. By focussing and enhancing the electric field , the plasma ions will preferentially sputter off the oxide at the whiskers, and do so more efficiently because of the glancing angles that the whisker presents.

At present the microdischarge regions (pockets) are formed between the compressed deuterated metal powder. We teach that these pockets can also be manufactured in the deuterated metal. This can be accomplished by any of a number of different methods. Holes can be etched, microdischarged, etc. in very thin honeycomb slabs or plates of the deuterated metal. The oxidized perforated plates can then be assembled so that the holes do not line up, and thus form small pockets.

Pulsing of the applied voltage provides an advantage in addition to reducing unwanted negative effects of heating. Although a low duty cycle with a pulse length as long as 1 millisecond will reduce heating effects, shorter pulses are

preferable for another very important reason. Our teaching is that pulsing in itself is important because it allows for a higher breakdown voltage and hence higher electric field for energizing the d's. Thus we teach that pulses of duration less than 1 msec will produce superior results.

The voltages used by Claytor et al ranged from between 500 V to 3000 V. The practice of our teachings would allow the voltage to increase to more than 10 kV with greatly increased fusion rates.

In order to maximize the fusion rates, the D_2 density in the gas pockets, and of the deuterated metal powders such as PdD should be at densities higher than the density corresponding to 10 atmospheres pressure. This should also serve to replace depleted D's more rapidly at the solid surface, and to maintain a high density of D's at higher temperature. The higher pressure also serves to increase the voltage prior to discharge.

Choice of the metal powder whose deuterated surface forms the target for fusion is important in that the metal should have a high value of D solubility and density at higher temperature ~ 100 to 500 °C for practical energy generation. Thus in addition to Pd and Ti, other metals or metal glasses may be used such as Zr, V, LaNi, TiFe, etc.

We teach the importance of whiskers (asperities, microprotrusions) on the surface of the deuterated metal. The whiskers serve to enhance and focus the electric field at their tips with a focusing of the d's to them. The field enhancement is approximately equal to the ratio of the whisker height to the tip ratio. With a high field enhancement, most of the voltage drop occurs within an ionic mean-free-path from the whisker. This serves to reduce the heat conduction loss as the plasma is not at a high temperature throughout a pocket, but only at the whiskers where the fusion interaction takes place.

In another embodiment of this invention, the whiskers themselves are made of a fusible isotope such as frozen D_2, or T_2 at a temperature less than 14 K. In the case of aneutronic (no neutrons) fusion reactions, some of the reactants are solid at room temperature. There are several advantages to having the

whiskers made of one of the fusion reactants, rather than just being metallic. First the reactant is present at a high density which is conducive to a high reaction rate. In addition to being bombarded by the other reactant, the discharge current in flowing through the whisker both heats it, and provides partial magnetic pinch confinement to the ensueing plasma. The magnetic pinch pressure is proportional to the square of the current flowing through the whisker, and inversely porportional to the square of the whisker radius.

The whiskers are produced by any of a number of different methods. The electrical discharge itself may both destroy existing whiskers and create new ones from the generated vapor. Whisker material is heated above the softening point, but just below the melting point (<14 K for D_2), and then a smaller electric field than the discharge electric field is applied. The electrostatic force acting on the softened fusible material will cause it to extrude out between the metallic powders to form whiskers. By means of a related, but different method, the electric field is applied to the fusible material at the melting point. Inhomogeneities in the field will cause the molten surfaces which cover the metallic oxide powders to become prickly with whiskers. Therefore upon cooling in the presence of the applied electric field, solid whiskers will be formed.

For convenience the device will primarily be described in terms of the deuterium fusion reaction. A number of other fusion reactions are possible, and the apparatus may operate with these reactions also. Table 2 lists other possible fusion reactions. Other than the D+D and D+T reactions, the other reactions shown are aneutronic (no neutrons). The aneutronic reactions have the advantage that no neutrons are produced, which otherwise would react with the apparatus making it radioactive.

Thus we have novel improvements which have not been anticipated by others, and which constitute our invention. We find that hitherto unconsidered physical mechanisms are present for the fusion to occur at the unexpectedly high observed levels. The implementation of and improvement upon these mechanisms is the basis for our invention as described herein in its many

embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view illustrating one embodiment of the solid state surface-micro-plasma fusion invention.

FIG. 2 shows an alternative embodiment of the present invention, in schematic view of a unit cell design.

FIG. 3 is a schematic view of another embodiment of this invention showing a two-unit cell design.

FIG. 4 shows breakdown voltage as a function of gap length.

FIG. 5 shows the breakdown electric field as a function of gap length.

FIG. 6 shows schematically a magnetic field superimposed perpendicular to the electric field applied to the device.

FIG. 7 shows whiskers on the cathodic surface of a microfusion pocket.

FIG. 8 illustrates the applied voltage as a function of time (not to scale) showing the sharp high magnitude discharge voltage pulse, and the low magnitude long duration whisker growing voltage.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The Solid State Surface-Micro-Plasma Fusion Device 10 shown in Fig.1 incorporates features novel to this invention. This device consists of alternating layers of the deuterated porous metal 1 and the porous insulator matrix 2 (of honeycomb type or pressed powder layer made of dielectric material) sandwiched between two metal electrodes 3 connected to a pulsed voltage source 4. The metal/insulator layers 1, 2 and the electrodes 3 surrounded by ceramic slabs 5 are placed in a ceramic-metal chamber 6 which contains pressurized D_2, T_2 and/or H_2 gas 7 introduced through the gas inlet 8. The entire device is maintained at an operating temperature < 500 °C by cooling with a heat exchange system (not shown). For D-D fusion, the thin porous layers 1, 2 are first saturated with pressurized D_2 gas 7. For D-H fusion, or D-T fusion, the thin porous layers 1, 2 are first saturated with pressurized H_2 or T_2 gas 7, respectively. After the metal layers 1 are saturated, H_2 or T_2 is replaced by pressurized D_2 (or a mixture of H_2/D_2 or T_2/D_2) gas

and pulsed voltage exceeding 10kV is applied. The D-H fusion has a practical advantage over the D-D fusion in that it does not produce any radioactive waste products. This is also true of the other aneutronic reactions listed in Table 2.

To withstand high gas pressure, the ceramic-metal chamber is constructed of metal and is coated or bonded on the inner surface with a ceramic insulator to prevent undesirable ionization of the gas in the space between the outer surfaces of the ceramic slabs and the inner surface of the ceramic-metal chamber. The ceramic-metal chamber may be of a modular design to connect to other pressurized ceramic-metal chambers for increased power generation and/or as parts of a gas circulation cooling and heat exchange system.

Figure 2 illustrates a unit cell 20 that can be used in an alternative design that does not require as high a voltage power supply as for Fig. 1. Shown are the porous deuterated metal layer 21, the porous insulator matrix 22, an optional insulator 23, a pulsed voltage source 24, and metal electrodes 25.

Figure 3 shows a two unit cell design 30, in which the unit cell 20 has been repeated twice. The unit cell 20 may be repeated as much as desired. A multi-unit cell assembly 30 has the feature of using many unit cells with alternating positive and negative electrodes as shown in Fig. 3. This design has the advantage of attaining as high an electric field with less total voltage requirement than the device of Fig. 1. Also shown are the porous deuterated metal layers 31, the porous insulator matrices 32, an optional insulators 33, pulsed voltage sources 34, and metal electrodes 35.

Figure 4 illustrates the breakdown volage as a function of gap length between the anode and cathode elelctrodes. Note that the voltage increases less quickly than the gap for large gaps.

Figure 5 shows the breakdown electric field as a function of gap length. Note the steepness of the curve at small gaps, indicating that much higher electric fields can be maintained at small gaps than for large gaps. This is one reason why the discharge regions are broken up into tiny pockets.

Figure 6 shows schematically a magnetic field B superimposed perpendicular to the electric field E applied to the device 10 of Fig. 1. The magnitude of the magnetic field is preferably greater than 4000 Oersteds. The magnetic field B spans the device. The magnetic field may be operated in a pulsed mode in synchronization with the pulsed voltage to enhance the fusion rate.

Figure 7 shows whiskers 43 on the surface of a microfusion pocket 40. One whisker is used to illustrate the focussing and enhancment of the electric field, E. The pocket 40 is surrounded by metallic powders of fusible isotopes 41 such as deuterated metallic powders. Also shown are the tiny reservoirs of fusible isotopes 42 for whisker formation and coating of the powders 41.

Figure 8 illustrates the applied voltage as a function of time showing the sharp high magnitude discharge voltage pulse, and the low magnitude long duration whisker growing voltage. This figure is not drawn to scale for either the voltage magnitude or the time duration.

While the invention has been described with reference to many embodiments, the descriptions are illustrative of the invention and are not to be construed as limiting the invention. Thus, various modifications and applications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

TABLE 1

ENERGY ENHANCEMENT BY DOUBLE BACKSCATTERING

Projectile Partner	Atomic Wt.	$(KE_f/KE_i)_1$	$(KE_f/KE_i)_2$
Boron (B)	11	5.4	29.2
Oxygen (O)	16	6.2	38.9
Sulfur (S)	32	7.3	52.5
Arsenic (As)	75	7.3	53.1
Iodine (I)	127	7.8	60.2
Tellerium (Te)	128	8.2	66.9
Thorium (Th)	232	8.3	68.9
Uranium (U)	238	8.3	68.9

TABLE 2

POSSIBLE FUSION REACTIONS and ENERGY RELEASE

$D + D \rightarrow T$ (1.01 MeV) + H (3.02 MeV)

$D + D \rightarrow {}^3He$ (0.82 MeV) + n (2.45 MeV)

$D + D \rightarrow {}^4He + \gamma$ (23.8 MeV)

$D + T \rightarrow {}^4He$ (3.5 MeV) + n (14.1 MeV)

$D + H \rightarrow {}^3He + \gamma$ (5.5 MeV)

$D + {}^3He \rightarrow {}^4He$ (3.6 MeV) + H(14.7 MeV)

$H + T \rightarrow {}^4He + \gamma$ (19.8 MeV)

$H + {}^6Li \rightarrow {}^4He$ (1.7 MeV) + ${}^3He$ (2.3 MeV)

$D + {}^6Li \rightarrow 2\ {}^4He$ + 22.4 MeV

$H + {}^{11}B \rightarrow 3\ {}^4He$ + 8.7 MeV

What is claimed is:

1. A method for producing nuclear fusion in a multitude of deuterated pockets in both series and parallel combination, comprising the steps of:

(a) introducing fusible nuclei in the gaseous state into the pockets;

(b) introducing heavy partner gases into the pockets;

(c) applying a pulsed electric field of high magnitude across the pockets;

(d) introducing whiskers on the discharge surfaces; and

(e) applying a magnetic field perpendicular to the applied electric field.

2. The method of claim 1 wherein the pockets are tritiated.

3. The method of claim 1 wherein the pockets are less than 10 mm in diameter.

4. The method of claim 1 wherein the magnetic field is pulsed.

5. The method of claim 1 wherein the whiskers are produced by an intermediate electric field applied between the applications of the discharge electric field.

6. A method for producing nuclear fusion in a multitude of hydrogen isotope absorbing pockets in both series and parallel combination, comprising the steps of:

(a) introducing fusible nuclei in the gaseous state at more than 10 atmospheres pressure into the pockets;

(b) applying a pulsed electric field of high magnitude across the pockets; and

(c) introducing whiskers on the discharge surfaces.

7. The method of claim 6 wherein the pockets are made of palladium.

8. The method of claim 6 wherein the pockets are made of titanium.

9. The method of claim 6 wherein the pockets are made

of zirconium.

10. The method of claim 6 wherein the pockets are made of vanadium.

11. The method of claim 6 wherein the pockets are made of LaNi.

12. The method of claim 6 wherein the pockets are made of TiFe.

13. The method of claim 1 wherein the pockets are formed from tritiated metal powders.

14. The method of claim 6 wherein the pockets are formed from deuterated metal powders.

15. The method of claim 1 wherein the pockets are made of tritiated metal powders with oxide coatings.

16. The method of claim 6 wherein the pockets are formed from deuterated metal powders with oxide coatings.

17. The method of claim 1 wherein the pockets are formed from stacks of 10 mm thick plates with a multitude of holes that do not line up.

18. The method of claim 6 wherein the pockets are formed from stacks of honeycombed plates with a multitude of holes that do not line up.

19. The method of claim 1 wherein the magnetic field is pulsed in synchonization with the aforesaid pulsed electric field.

20. A method for producing nuclear fusion in a multitude of pockets in both series and parallel combination having at least one unit cell, comprising the steps of:

(a) introducing fusible nuclei in the gaseous state into the pockets;

(b) connecting the unit cells electrically in alternating plus-minus polarity; and

(c) applying a pulsed electric field across the pockets.

21. The method of claim 20 wherein a magnetic field is applied perpendicular to the applied electric field.

22. The method of claim 20 wherein whiskers are introduced on the discharge surfaces.

23. The method of claim 20 wherein the whiskers are produced by application of an intermediate electric field between the discharge electric field.

24. Apparatus for providing nuclear fusion in a multitude of deuterated pockets in both series and parallel combination, comprising:

(a) pockets for fusible nuclei in the gaseous state;

(b) heavy partner gases in the pockets;

(c) whiskers on the discharge surfaces; and

(d) means for applying a pulsed electric field of high magnitude across the pockets; and

(e) means for applying a magnetic field perpendicular to the applied electric field.

25. An apparatus as in claim 24 wherein the pockets are tritiated.

26. An apparatus as in claim 24 wherein the pockets are less than 10 mm in diameter.

27. An apparatus for producing nuclear fusion in a multitude of hydrogen isotope absorbing pockets in both series and parallel combination, comprising:

(a) fusible nuclei in the gaseous state at more than 10 atmospheres pressure into the pockets;

(b) means for a pulsed electric field of high magnitude across the pockets; and

(c) whiskers on the discharge surfaces.

28. The apparatus of claim 27 wherein the pockets are made of palladium.

29. The apparatus of claim 27 wherein the pockets are made of titanium.

30. The apparatus of claim 27 wherein the pockets are made of zirconium.

31. The apparatus of claim 27 wherein the pockets are made of vanadium.

32. The apparatus of claim 27 wherein the pockets are made of LaNi.

33. The apparatus of claim 27 wherein the pockets are

made of TiFe.

34. The apparatus of claim 27 wherein the pockets are formed from tritiated metal powders.

35. The apparatus of claim 27 wherein the pockets are formed from deuterated metal powders.

36. The apparatus of claim 27 wherein the pockets are made of tritiated metal powders with oxide coatings.

37. An apparatus for producing nuclear fusion in a multitude of pockets in both series and parallel combination having at least one unit cell, comprising:

(a) fusible nuclei in the gaseous state in the pockets; and

(b) unit cells connected electrically in alternating plus-minus polarity; and

(c) means for a pulsed electric field across the pockets.

38. Apparatus of claim 37 with means for applying a magnetic field perpendicular to the applied electric field.

39. Apparatus of claim 37 wherein whiskers are present on the discharge surfaces.

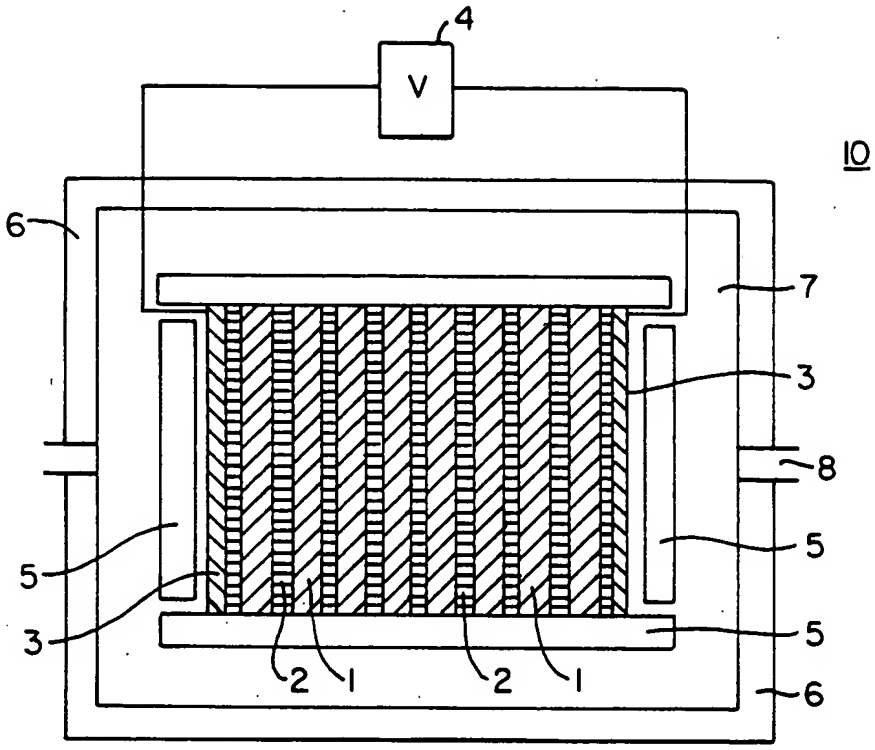

FIG. 1.

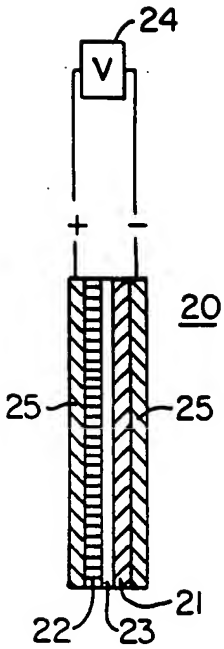

FIG. 2.

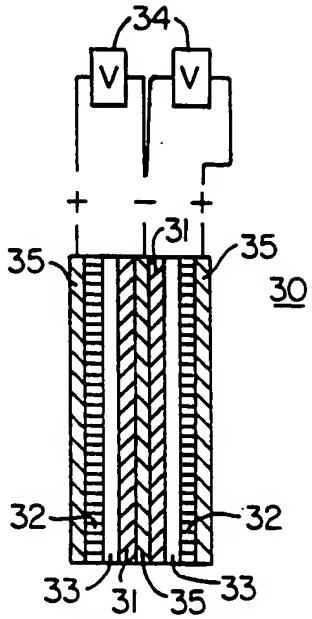

FIG. 3.

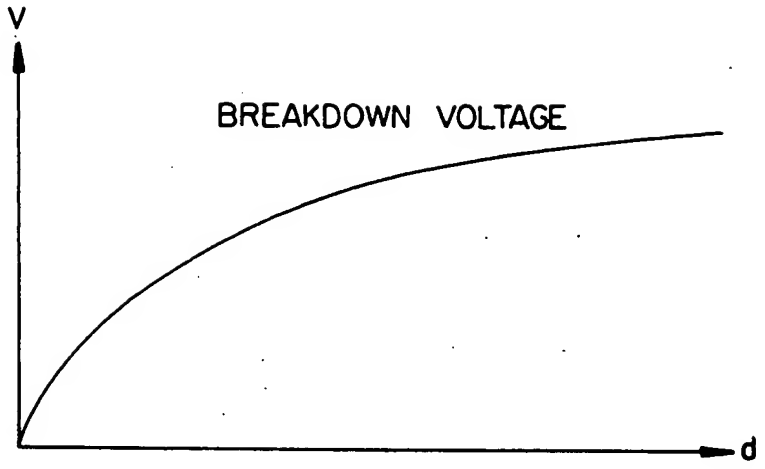

FIG. 4.

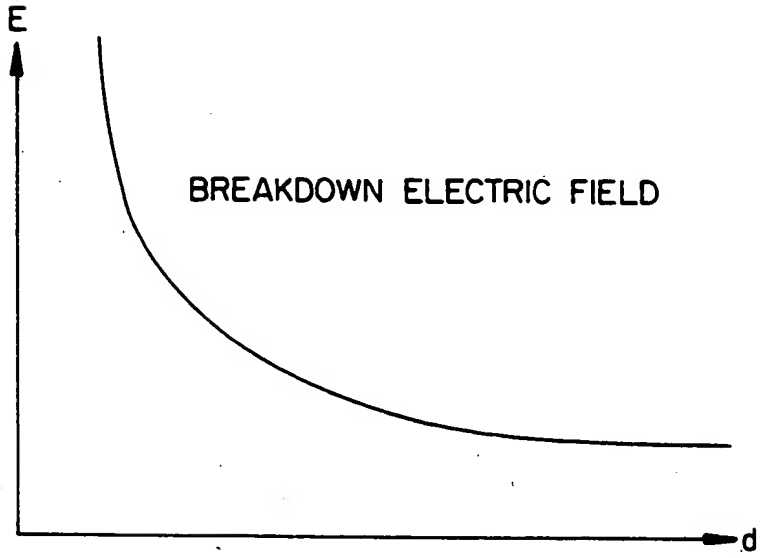

FIG. 5.

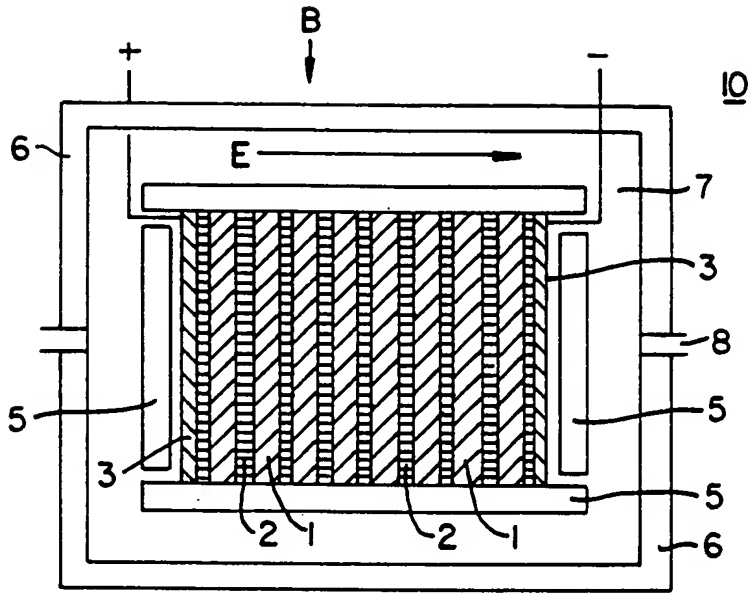

FIG. 6.

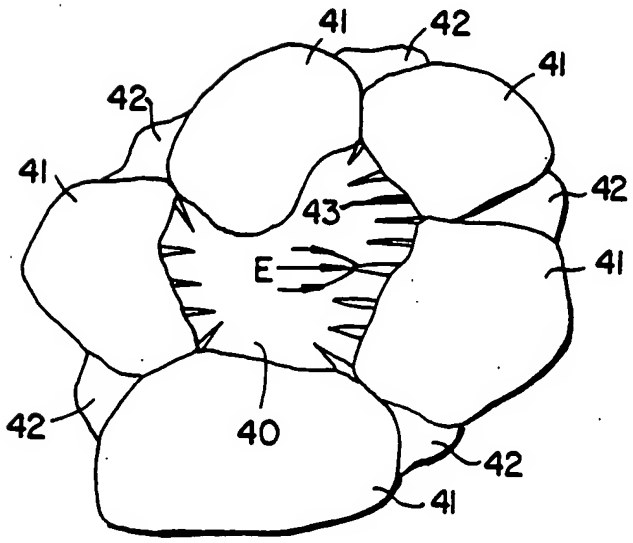

FIG. 7.

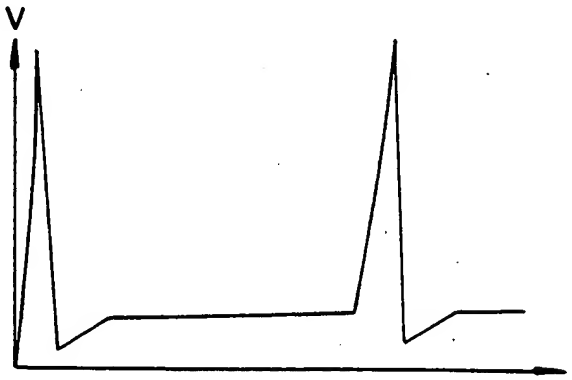

FIG. 8.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/04498

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :G21B 1/00 .
US CL :376/100
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 376/108; 204/129,129.43,290R,290F,292; 205/257,265

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FUSION TECHNOLOGY, VOL. 18, AUGUST 1990, BOCKRIS ET AL, PAGES 11-31 (NOTE PARTICULARY PAGES 23,24,28)	1-39
Y	INT. J. HYDROGEN ENERGY, VOL. 15, NO. 8, (1990), LIN ET AL, PAGES 537-550, (NOTE PAGES 537,546,547)	1-39
Y	WO,A 90/14669 (HAEFFNER) 29 NOVEMBER 1990 (See entire document)	1-39
Y	WO,A 90/015416 (EDWARDS) 13 DECEMBER 1990 (SEE THE ABSTRACT AND PAGE 2)	1-39
Y	GB,A 2,231,195 (ASPDEN) 07 NOVEMBER 1990, (NOTE PAGES 12,23-25)	1-39
L	JOURNAL OF FUSION ENERGY, VOL. 9, NO. 3, SEPTEMBER 1990, BESENBACHER ET AL, PAGES 315-317 (CITED AS CASTING DOUBT ON INDUCING NUCLEAR FUSION BY FORCING DEUTERIUM INTO A HYDROGEN ISOTOPE ABSORBING MATERIAL).	1-39

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 29 JULY 1992	Date of mailing of the international search report 21 OCT 1992
Name and mailing address of the ISA/ Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer HARVEY E. BEHREND Telephone No. (703) 308-0439

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/04498

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A 4,568,509 (CRIJANOVICH ET AL) 04 FEBRUARY 1986 (See entire document)	1-39
Y	WO,A 91/06959 (SADOWAY) 16 MAY 1991 (NOTE PAGES 4-7)	1-39
Y	WO,A 90/13128 (RABINOWITZ ET AL) 01 NOVEMBER 1990 (See entire document)	1-39
A	J. AMER. CHEM. SOC., VOL. 56, DECEMBER 1934, SMITH ET AL, PAGES 2513-2525	
Y	WO,A 90/015415 (COUPLAND ET AL) 13 DECEMBER 1990 (See entire documents)	1-39
A	EP,A 0,129,734 (BEAVER ET AL) 01 FEBRUARY 1985	
A	US,A 3,445,845 (WICKE ET AL) 15 JULY 1969 (SEE COL. 2 LINES 67-71)	
Y	US,A 4,675,145 (KUSWA ET AL) 23 JUNE 1987 (See entire documents)	1-39
Y	EP,A 0,393,465 (YAMAZAKI ET AL) 24 OCTOBER 1990 (See entire documents)	1-39
A	US,A 4,160,704 (KUO ET AL) 10 JULY 1979	
A	US,A 3,520,788 (PAEHR) 14 JULY 1970	
A	US,A 3,396,091 (LYONS, JR., ET AL) 06 AUGUST 1968 (NOTE COL. 4 LINES 17-23)	